IODP Proposal Cover Sheet

Amundsen Sea Ice Sheet history

839 - Full

Title	Development and sensitivity of the West Antarctic Ice Sheet tested from drill records of the Amundsen Sea Embayment
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Abstract

The West Antarctic Ice Sheet (WAIS) is largely marine-based and, thus, highly sensitive to climatic and oceanographic changes. It probably had a very dynamic history over the last several million years. A complete collapse of the WAIS would result in a global sea-level rise of 3.3-4.3 meters, yet, the worlds scientific community (e.g. IPCC 5th Assessment Report 2013) is not able to predict its future behaviour. Moreover, knowledge about past behaviour of the WAIS is poor, in particular during geological times with climatic conditions similar to those expected for the near and distant future. Reconstructions and quantifications of partial or complete WAIS collapses in the past are urgently needed for constraining and testing ice sheet models that aim to predict future WAIS behaviour and the potential contribution of the WAIS to global sea-level rise. Large uncertainties exist regarding the chronology, extent, rates, and spatial and temporal variability of past advances and retreats of the WAIS across the continental shelves. These uncertainties mainly result from the fundamental lack of data from drill cores recovered proximal to the WAIS. The continental shelf and rise of the Amundsen Sea are prime targets for drilling, because the records are expected to yield archives of pure WAIS dynamics unaffected by other ice sheets, and the WAIS sector draining into the Amundsen Sea Embayment (ASE) currently experiences the largest ice loss in Antarctica. A series of drill sites are proposed for the ASE shelf where seismic data reveal oceanward dipping sedimentary sequences that span the time from the pre-glacial depositional phase to the youngest glacial periods. Our strategy is to drill transects from the oldest sequences close to the bedrock-basin boundary at the middle-inner shelf transition to the youngest sequences on the outer shelf in both the western and the eastern ASE. These transects will provide a detailed history of the glacial cycles in the Amundsen Sea region and allow comparison to the WAIS history known from the Ross Sea sector. In addition, deep-water sites on the continental rise of the Amundsen Sea are selected for recovering continuous records of glacially transported sediments and detailed archives of climatic and oceanographic changes throughout glacial-interglacial cycles. We will apply a broad suite of analytical techniques, including multi-proxy analyses, to address our objectives of reconstructing the onset of glaciation in the greenhouse to icehouse transition and processes of dynamic ice sheet behaviour during the Neogene and Quaternary.

Scientific Objectives

Five principal objectives of the proposal are summarized:

1) We aim to reconstruct the glacial history of West Antarctica from the Paleogene to the Holocene and the dynamic behavior of the West Antarctic Ice Sheet (WAIS) during the Neogene and Quaternary, especially possible partial or full WAIS collapses, and the WAIS contribution to past sea-level changes. Emphasis is placed in particular on studying the response of the WAIS at times when the pCO2 in Earth's atmosphere exceeded 400 ppm and atmospheric and oceanic temperatures were higher than at present.

2) We plan to correlate the WAIS-proximal records of ice sheet dynamics in the Amundsen Sea with global records of ice volume changes and proxy records for air and seawater temperatures.

3) We will study the relationship between incursions of warm Circum-Polar Deep Water (CDW) onto the continental shelf of the Amundsen Sea Embayment and the stability of marine-based ice sheet margins.

4) We will reconstruct the processes of major WAIS advances onto the middle and outer shelf that presumably occurred since the middle Miocene, and compare their timing and processes to those of other Antarctic shelves.

5) We will search for evidence for the first ice sheet expansion onto the continental shelf of the Amundsen Sea Embayment and its possible control by the uplift of Marie Byrd Land.

Non-standard measurements technology needed to achieve the proposed scientific objectives.

Proposed Sites

Site Name	Position (Lat, Lon)	Water Depth (m)	Penetration (m)			Brief Site-specific Objectives
			Sed	Bsm	Total	
ASRE-03A	-69.778, -103.275	4084	1400	0	1400	onset of major glaciation; mid-Miocene climate optimum; high-resolution record; correlation with paleo-current reconstruction
ASRE-01B	-70.242, -103.718	3820	950	0	950	major glacial and warm periods from mid-Miocene climate optimum to early Pliocene warm period to present; high-resolution record of Plio/Pleistocene
ASRE-02B	-70.528, -102.394	3060	950	0	950	major glacial and warm periods from mid-Miocene climate optimum to early Pliocene warm period to present; high-resolution record of Plio/Pleistocene
ASRW-01B	-71.713, -120.452	2545	900	0	900	major glacial and warm periods from early Pliocene warm period to present, high-resolution record
ASRE-04A	-70.242, -105.775	3600	900	0	900	major glacial and warm periods from early Pliocene warm period to present; high-resolution record; correlation with paleo-current reconstruction

ASRE-05A	-70.075, -108.724	3825	1200	0	1200	onset of major glaciation; mid-Miocene climate optimum; high-resolution record; correlation with paleo-current reconstruction
ASRE-06A	-70.325, -114.223	3466	1200	0	1200	onset of major glaciation; mid-Miocene climate optimum; high-resolution record; correlation with paleo-current reconstruction
ASSE-09A	-72.910, -107.307	690	900	0	900	transition from preglacial to glacial; timing of onset of major West Antarctic glaciation
ASSE-01B	-72.918, -107.797	614	900	0	900	transition from preglacial to glacial; timing of onset of major West Antarctic glaciation; records of Marie Byrd Land dome uplift in relationship to early glacial phases
ASSE-02C	-72.848, -106.347	576	900	0	900	greenhouse-to-icehou se transition; Eocene-Oligocene climate gradient; timing of early West Antarctic glaciation; records of Marie Byrd Land dome uplift in relationship to early glacial phases
ASSW-01B	-72.993, -115.792	710	600	0	600	timing of onset of glaciation; transition from preglacial to glacial; mid-Miocene climate optimum; records of Marie Byrd Land dome uplift is relationship to early glacial phases
ASSW-02B	-72.817, -116.583	654	900	0	900	transition to full glacial conditions; CDW events; early Pliocene warm period; transition to cooling in late Pliocene
ASSW-03B	-72.502, -117.972	538	850	0	850	full glacial conditions; CDW events; late Pliocene cooling
ASSE-10A	-72.572, -107.267	733	900	0	900	transition to full glacial conditions, CDW events; early Pliocene warm period, transition to cooling in late Pliocene
ASSE-03B	-72.582, -108.002	578	850	0	850	transition to full glacial conditions; CDW events; early Pliocene warm period; transition to cooling in late Pliocene; records of Marie Byrd Land dome uplift is relationship to early glacial phases
ASSE-04B	-72.558, -106.448	538	900	0	900	transition to full glacial conditions; CDW events; early Pliocene warm period; transition to cooling in late Pliocene; records of Marie Byrd Land dome uplift in relationship to early glacial phases
ASSE-11A	-72.022, -107.588	585	700	0	700	transition to full glacial conditions; CDW events; early Pliocene warm period; transition to cooling in late Pliocene
ASSE-05C	-72.149, -108.436	582	800	0	800	transition to full glacial conditions; CDW events; early Pliocene warm period; transition to cooling in late Pliocene; records of Marie Byrd Land dome uplift in relationship to early glacial phases
ASSE-06B	-71.893, -105.552	514	950	0	950	transition to full glacial conditions; CDW events; early Pliocene warm period; transition to cooling in late

-	-	-	-	-	-	Pliocene; records of Marie Byrd Land dome uplift in relationship to early glacial phases
ASSE-12A	-71.332, -108.365	495	600	0	600	full glacial conditions, CDW events; late Pliocene cooling
ASSE-07B	-71.287, -104.750	540	600	0	600	full glacial conditions, CDW events; late Pliocene cooling
ASSE-08B	-71.618, -113.200	645	950	0	950	full glacial conditions, CDW events; late Pliocene cooling